Improving Public Health with Industrial Engineering and Operations Research

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What Happened? Finding Patterns in Data

Organizations that have large collections of data about persons and their activities can run standard reports on these data sets to monitor their operations and support routine decision-making. In addition, users may submit queries to obtain data for answering questions that they develop. Finding patterns that are not even imagined, however, requires more sophisticated techniques such as data mining.

FluView tracks seasonal influenza activity across the United States and summarizes this activity using a variety of key indicators (CDC, 2014).

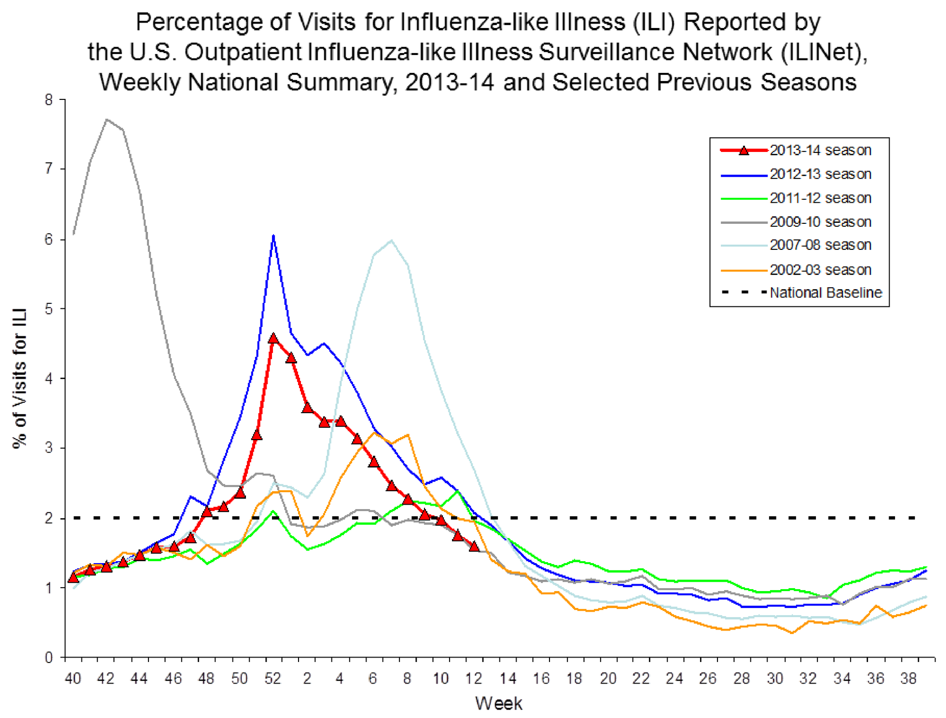


Figure credit: CDC (April 1, 2014).

ESSENCE II is a syndromic surveillance system that collects and analyzes public health indicators for early detection of disease outbreaks (Lombardo *et al*., 2004).

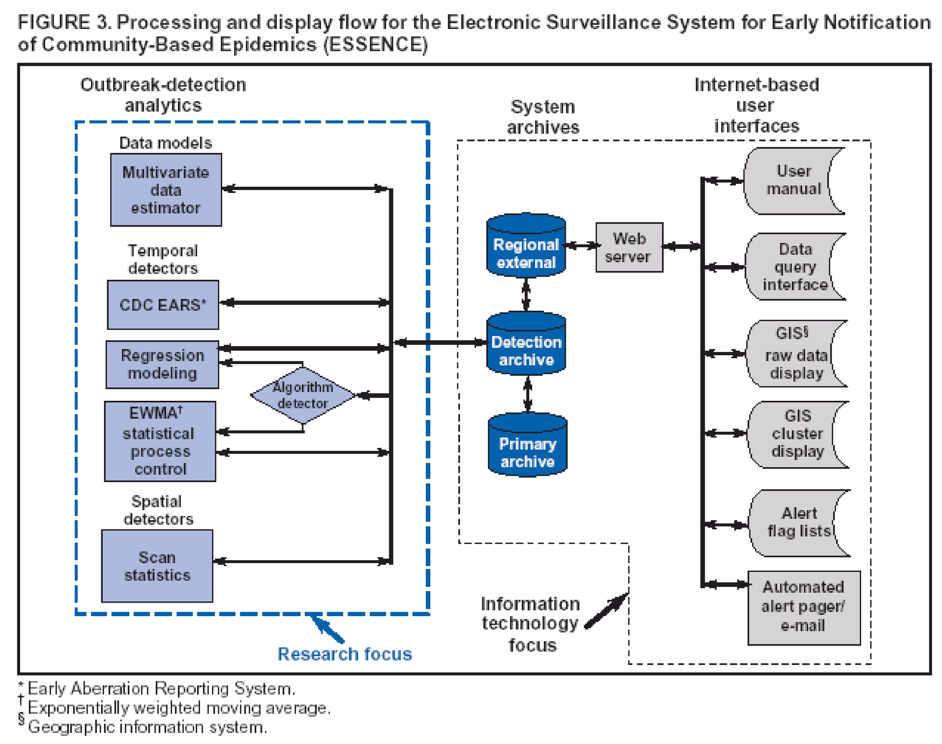
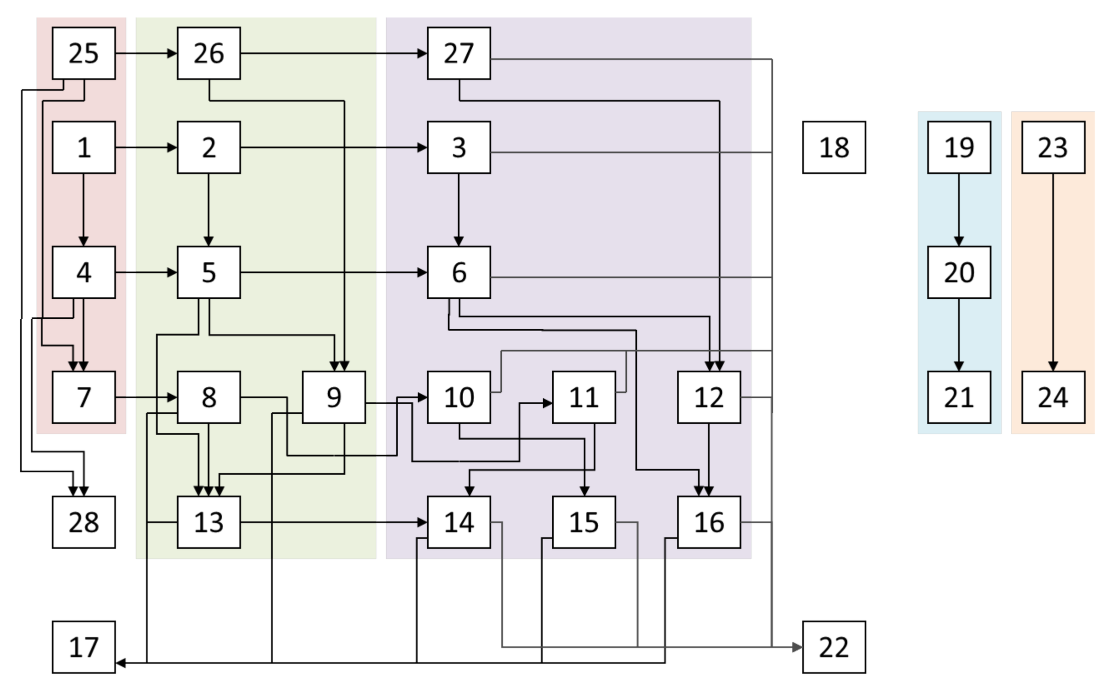


Figure credit: Lombardo *et al*. (2004).

What Could Happen? Building Stochastic Models

Understanding what could happen often requires considering the uncertainty of future events. Stochastic models can be used to identify the distribution of possible outcomes of a process (as in risk analysis) and to estimate the performance of a system in which the events are random (for example, queueing models). Detailed simulation models can sample the relevant random variables and evaluate the associated system performance.

A stochastic compartment model was used to estimate the number of deaths from an aerosolized anthrax attack when pre-positioned medication was used for prophylaxis. Reducing the number of potential exposures who seek prophylaxis allows those truly exposed to receive medication sooner, which saves lives.



A schematic of the compartment model (Herrmann and Houck, 2011).

A simulation model was used to evaluate the capacity and cost of a mass influenza (or pneumococcal) vaccination clinic to be setup in North Carolina. The results showed that staffing was sufficient for 15,000 people in 17 hours. This was used to justify reimbursement from HHS.

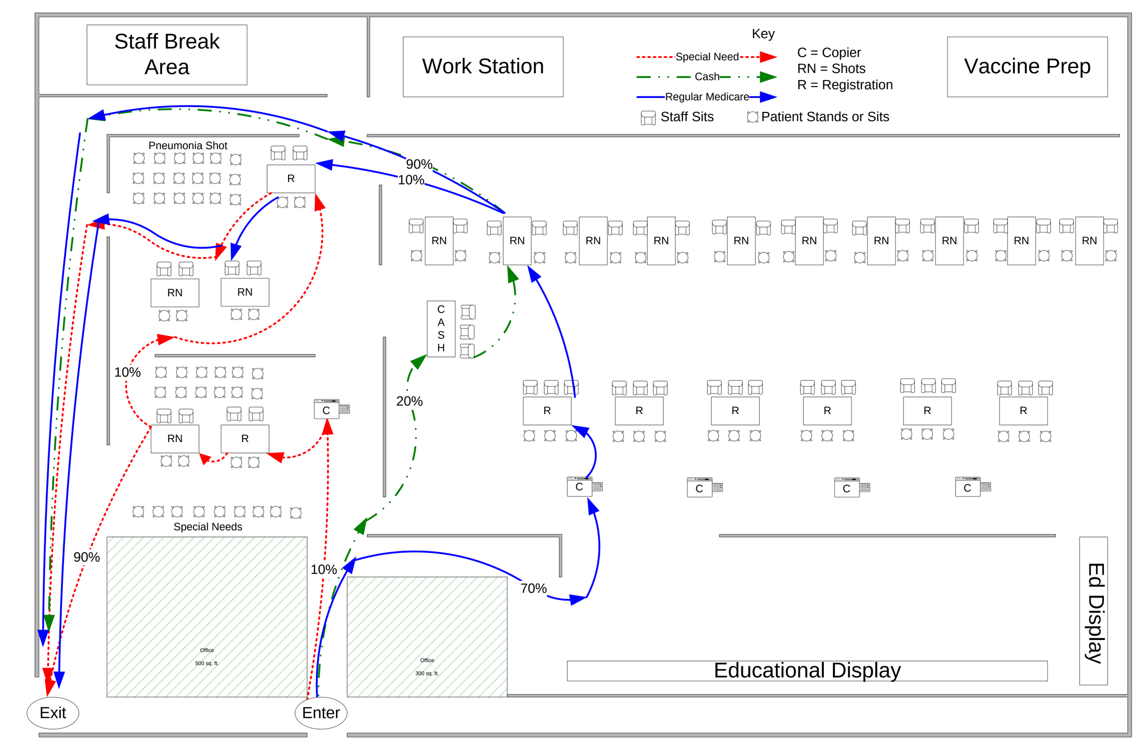


Figure credit: Washington (2014).

What Should We Do? Making Decisions

Although decision-making is sometimes easy, it can be difficult when the decision requires considering many alternatives, many interacting issues, multiple criteria, or uncertainty in the outcomes. Models that provide insight into what has happened and models that predict what could happen yield valuable information for decision makers.

An analysis of the costs associated with vaccinations for diphtheria, tetanus, pertussis, Haemophilus influenzae, polio, measles, mumps, and rubella, hepatitis B, and varicella showed that the current routine childhood immunization schedule results in substantial cost savings in the United States (Zhou *et al*., 2005).

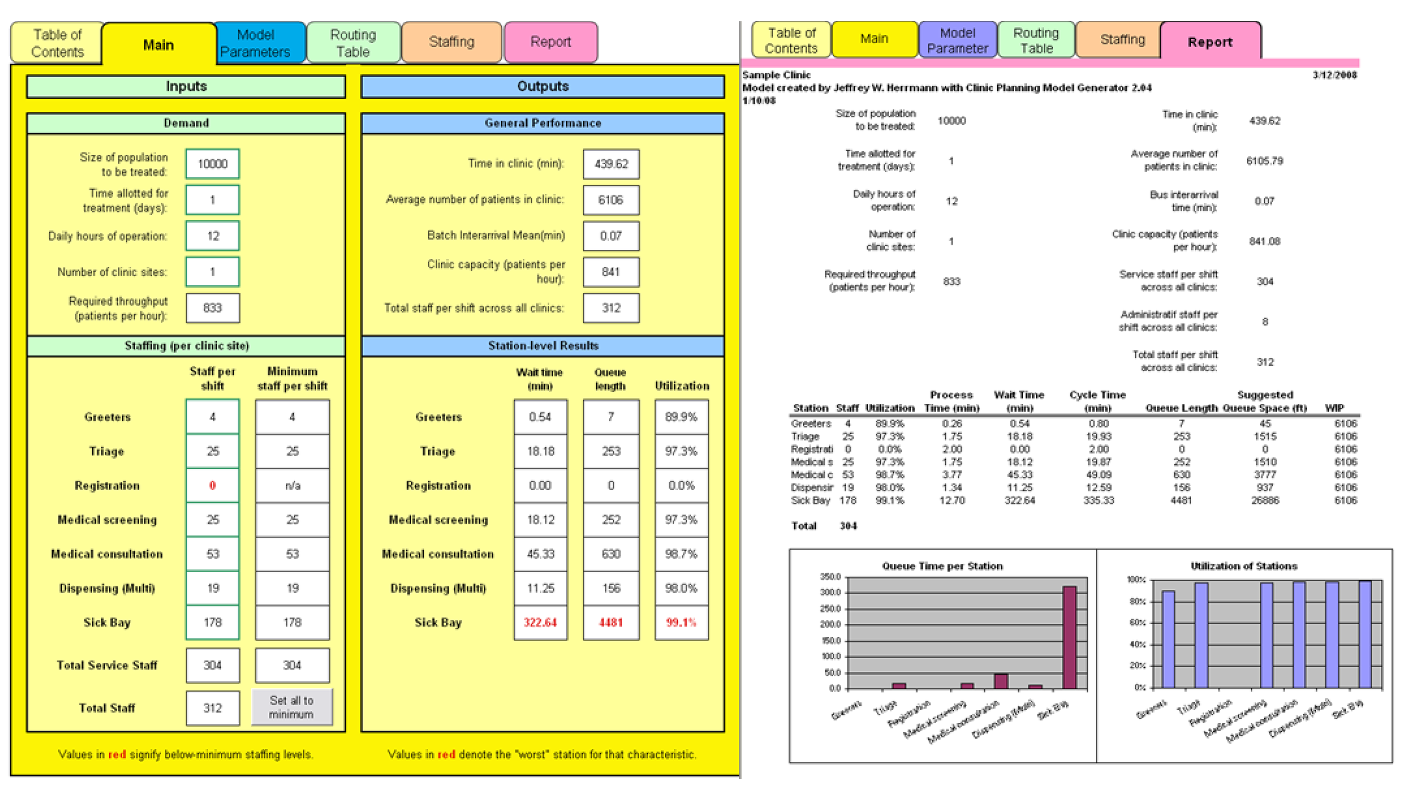
Table 5. Summary of Costs and Benefit-Cost Ratios*

	Direct Costs (Million), $	Societal Costs (Direct + Indirect) (Million), $
Disease costs without immunization program	12 307	46 557
Disease costs with immunization program	133	482
Costs averted	12 175	46 075
Immunization program costs†	2293	2789
Net present value (net savings)	9881	43 286
Benefit-cost ratio	5.3:1	16.5:1

*All costs are given in US dollars.
†Direct program costs included vaccine, administration, parent travel, and direct costs for treatment of adverse events. Societal costs included direct program costs and parent time lost for vaccination and treatment of adverse events.

Table credit: Zhou *et al*. (2005).

The Clinic Planning Model Generator software creates a Microsoft Excel workbook for planning Points of Dispensing (PODs). Public health planners in 25 states have used the software to evaluate and improve their POD plans. This can be used for emergency preparedness planning or to support an ongoing campaign.



A Clinic Planning Model predicts the capacity and congestion in a POD based on expected staffing and arrival rate (Herrmann, 2008).

What is the Best Solution? Solving Problems with Optimization

Optimization is essentially a search technique that is most appropriate when the set of possible solutions is large and complex and evaluating a possible solution requires significant effort. Using optimization requires identifying the decision variables, formulating the constraints, determining the objective function, and then finding the optimal solution.

An optimization tool can help physicians determine the best catch-up schedules for childhood immunization. These schedules ensure that a child continues to receive the most coverage against vaccine preventable diseases in the least amount of time if one or more doses have been delayed (Engineer *et al*., 2009).

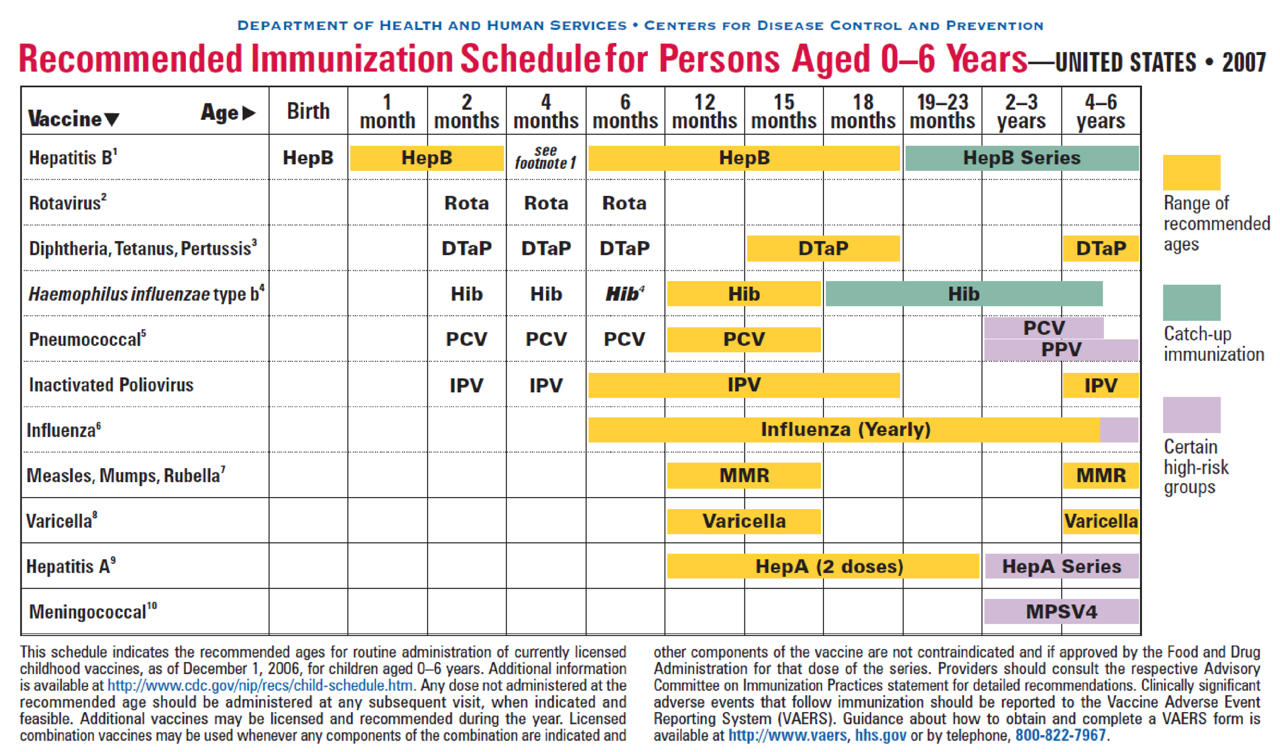
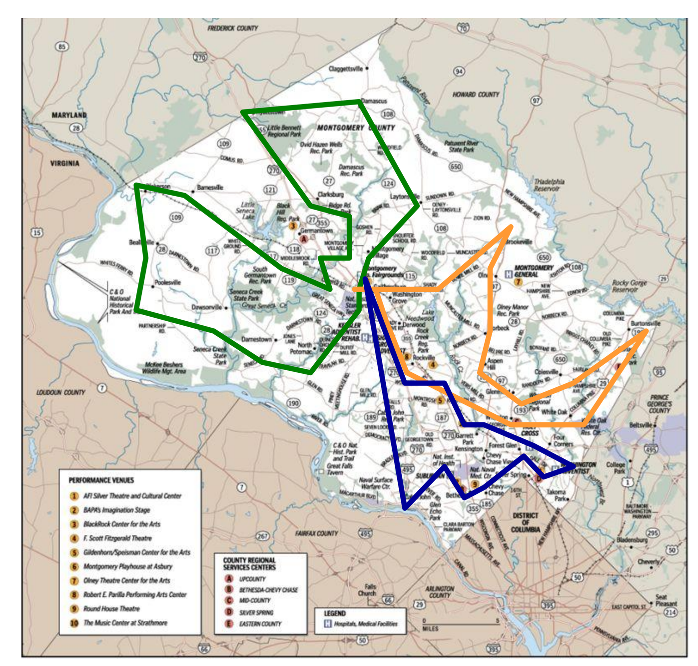


Figure credit: Engineer *et al*. (2009).

The Inventory Slack Routing Problem (ISRP) creates plans for delivering medication quickly during a public health emergency. The planning goal is to deliver material as early as possible to demand sites from a central depot at which material arrives over time (Montjoy and Herrmann, 2012).



A notional solution to an instance of the ISRP in Montgomery County, Maryland.